# A Research Plan for Blister Rust Resistance in Eastern White Pine (*Pinus strobus* L.)

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## INTRODUCTION

White pine (WP) blister rust (BR) is one of the major reasons for the declining abundance of eastern white pine (EWP, *Pinus strobus* L.) in Ontario. Despite of various silvicultural measures, such as the eradication of ribes, pruning, and the application of fungicide (Gross 1985), effective ways to control the epidemic of BR are still uncertain. To be operational useful, any WPBR control method, however, has to prove its biological efficacy, economic efficiency and environmental acceptance.

Controlling BR through the deployment of disease resistant WP genotypes can be a very economical approach. Once durable genetic resistance is developed, genotypes can be used endlessly in propagation through both sexual and asexual means, resulting in a one-time investment and long-term benefiting consequence. Impressive progress in developing BR resistance in sugar pine (*P. lambertiana*) (Kinloch and Byler 1981) and west white pine (*P. monticola*)(Fins et al. 2001; Sniezko and Kegley 2002a) provides stimuli for pursuing similar work in EWP, although some of the mechanisms for resistance have yet to be confirmed.

## EFFECTIVE BLISTER RUST RESISTANCE MECHANISMS

Mechanisms for BR resistance have been well documented (Hoff and McDonald 1972, 1975; Kinloch and Litylefield 1976; Kinloch et al. 1999; Sniezko and Kegley 2002b). Perhaps the most effective mechanism is the hypersensitive reaction (HR) shown as major gene(s) resistance (MGR), which constitutes the first front of defense. An example of HR is the quick needle death after infection that prevents disease from moving into stems. HR is especially evident in *P. armandii* (Hoff and McDonald, 1972,1975), an Asian 5-needle pine species which usually becomes BR frees not long after inoculating with BR. Although EWP needles also die and break occasionally at the spots of BR infection, it happens in much longer a period after some disease development, which provides the opportunities for the pathogen to move into branch/stem. A disappointment in EWP is that not all infected needles behave similarly, some of them die and/or break relatively quickly while others bear the disease until the death of a seedling. The likelihood of stem canker development in EWP seedlings depends, therefore, the abundance of basideospores, the distance of an infection spot to needle sheath, and the reaction of an individual needle. In our inoculation of 2-year-old seedlings, with a dosage of >5,000 basideospores/cm$^2$, many open-pollinated progeny from 25 putative resistant parents developed stem canker in less than 3-months.

The second notable resistance mechanism is slow-rusting through bark-reaction (Sniezko and Kegley 2002b). Under such mechanism, stem cankers are limited to enlarge so that they do not gird a tree. EWP shows considerable bark reaction as many inoculated 1 to 2-year-old seedlings had signs of stem swelling and shoot sprouting from dormant buds. Bark reaction, however, does not necessarily guarantee the survival of EWP from BR infection as many seedlings still die after showing bark reaction.

## A Research Strategy for BR Resistance in EWP

The lack of confirmation of obvious MGR resistance in EWP could be attributed to: *i*) the small sampling sizes of genotypes so far screened or *ii*) the lack of BR resistant alleles in the species. Unlike the large number of genotypes screened in sugar pine and western white pine (Sniezko and Kegley 2002a), the number of genotypes screened in EWP is relatively small. Due to the rarity of resistant alleles (Kinloch 1991; Kinloch and Dupper 2002), there is chance that resistant alleles in EWP may have not been sampled. This leads to the needs for extensive screening of EWP for MGR. On the other hand, the failure to identify MGR in EWP from several programs may have suggested that there actually is no resistant allele in EWP. This assumption justifies an approach to introduce resistant alleles from other WP species through traditional plant breeding methods, such as hybridization followed by back crosses.

Based on the first assumption, we plan to search for MGR through artificial inoculation of a large number 6-month to 1-ear-old EWP seedlings with broad genotype representations. These include seeds from selected putative resistant trees from gene-banks, selected superior EWP trees in tree improvement programs, seeds from natural populations, and new selections of putative resistant trees at high BR hazard sites.

With the second assumption, we plan to continue the effort of introducing BR resistant alleles to EWP through interspecific hybridization followed by back-crossing. The objectives are to retain BR resistant alleles in EWP while reducing the non-strobus genome to less than 1/16 –1/32 in 4 to 5 generations. The final hybrids are expected to have almost identical appearance, growth performance, adaptation and wood quality to EWP. Among the hybrids created in Ontario between the 1950s and 1980s, we have identified a number of 2$^{nd}$ to 3$^{rd}$ generation hybrids with high BR resistance, vigorous growth and theoretical genome composition of 75%-87.5% as *P. strobus*. For future breeding, some candidates of 5-needle pine species with high BR resistance are listed in Table 1. A general diagram of our screening and testing scheme is illustrated in Figure 1.

Table 1. BR resistant 5-needle pine species as candidates for interspecific hybridization with EWP.

| Species | Natural Distribution | Remarks |
|---|---|---|
| *P. armandii* | Western China | Tolerable to –30˚C, up to 30m, highly resistant to BR. |
| *P. bunceana* | Central China | Tolerable to –30˚C, up to 35m, no reported threat from BR. |
| *P. griffithii* | Himalayan region | Survived in southern ON, up to 50m, resistant to BR. |
| *P. koraiensis* | Northeastern Asia | Very cold-hardy, up to 35m, no reported threat from BR. |
| *P. peuce* | SE Europe | Survived in southern ON, up to 20m, some resistance to BR. |

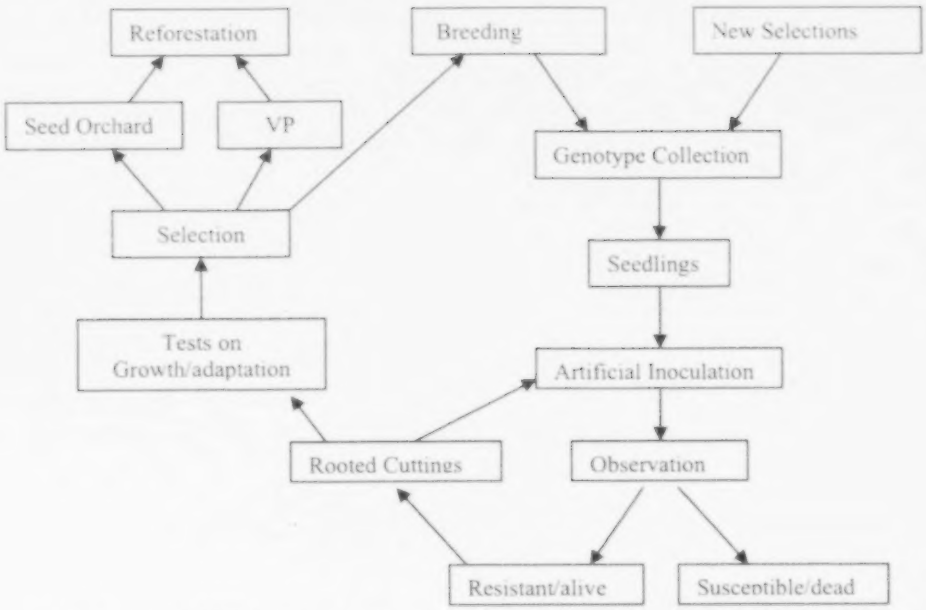


Figure 1. A diagram of BR resistance research in EWP at the Ontario Forest Research Institute (OFRI).

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